The 8th Annual Conference of the PHM Society

phmsociety

Panel Discussion on:

Automotive PHM & Advanced Analytics

4-Oct-2016, 1:15-3:00 PM MDT

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Agenda

- Purpose & scope of today's panel
- Future **Automotive PHM** Interest Group suggested?
- Brief introduction of panelists with their own statements:
  - Background & interests (5-7 minutes each)

➔ Audience questions & discussion

Panel Description

- PHM technology has entered production use in the automotive domain and is expected to become increasingly important for:
  - Advanced Diagnostics &
  - True Prognostics
- Our scope includes the opportunities and barriers to the growth of PHM for commercial and, possibly, fleet applications.
- This panel is highly qualified to address the critical role suppliers will need to play in collaboration with the OEMs/Integrators to maximize the value to themselves but more importantly to the end customer.
- The power of Advanced Analytics further expands the scope & illustrates the paradigm shifting nature of the opportunity before us.

Need for Collaboration

- Given the emergence & growing importance of PHM systems across a variety of industries, how can OEMs and Suppliers best collaborate to:
  - Speed introduction of PHM functionality for maximum customer/user benefit
  - Maximize system coverage, scalability & accuracy
  - Avoid inefficiencies & wasteful duplication of effort
  - Clarify coordination & communication needs
  - Ensure that data is used as agreed by stakeholders and is secure
  - Respect privacy & regulations relative to operator performance tracking

Additional PHM Issues

- Diagnosis vs. Prognosis Paradigm
- Value proposition for prognostics is multifaceted
- “Perceived reliability” captures the impact on users
- All components for all systems are at risk from Day 1 and prognostics can mitigate those risks
  - Not all failure modes can be reasonably prognosed
  - Prognosis is akin to doing an inspection
- VHM must compete with established traditional organization structures & existing work processes (e.g., Engineering Design)
  - Organization→ Decisions→ Budget & Timing

Steve Holland

- Currently, Research Fellow, Vehicle Health Management at GM Global R&D
- 40+ years of experience at GM in R&D and Manufacturing Eng./Robotics
- Previously R&D Director: application of PHM to improve GM plant throughput (4 yrs)
- Chief Technologist: applying PHM technologies to GM vehicles (10 yrs)
- Bachelors/EE from Kettering & Masters/CS from Stanford
- PHM Board of Directors & Member of PHM International Scientific Committee
- SAE Member: HM-1 IVHM Standards & IVHM Steering Committee
- Professional Engineer & IEEE Fellow

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SAE Standards Work

Draft

JA6268 Design & Online Communication Standards for Health Ready Components

SAE INTERNATIONAL

AEROSPACE & AUTOMOTIVE RECOMMENDED PRACTICE

JA6268	REV. 0

Issued	14-June-2016 Draft
Revised	N/A
Reaffirmed	N/A
Stabilized	N/A
Cancelled	N/A

Superseding N/A

Design & Online Information Exchange Standard for Health-Ready Components

RATIONALE

This Aerospace Recommended Practice (ARP) was created to help reduce existing barriers to the successful implementation of Integrated Vehicle Health Management (IVHM) technology into the aerospace and automotive sectors. The principal motivation for this ARP is to facilitate the introduction of enhanced IVHM functionality relating to supplier-provided components to better meet the needs of end users and government regulators in a cost effective manner. Underlying this motivation, is the assumption that market forces will drive the need to acheive IVHM's benefits and will in turn drive new requirements which suppliers must ultimately meet. This ARP has two primary objectives: (1) to encourage the introduction of a much greater degree of IVHM functionality in future vehicles at a much lower cost, and (2) to address ligitimate intellectual property concerns by providing recommended IVHM design-time data specification and exchange alternatives in an effort to help unlock the potential of IVHM.

IVHM Capability Levels for Aerospace/Automotive

Draft

SAE Level	Vehicle Health Capability	Narrative Description	Participation in Repair Actions	Key Data Resources	Availability of Logged &/or Real-Time Data	Use of Supporting Models	IVHM System Characteristics
Manual Diagnosis & Repair Process performed by Technician							
0	Limited On-Vehicle Warning Indicators	Service actions for scheduled maintenance or when Operator notices problems or is alerted by indicator lights or simple gages.	**Operator/Driver & Service Tech**	On-Vehicle Measurements & Observation	N/A	Paper-based Manuals	Only Manual Diagnostic Tools & No Condition-Based Services
1	Enhanced Diagnostics Using Scan Tools	Service techs gain added diagnostic insight using automated scanners to extract vehicle operating parameters & diagnostic codes	Operator/Driver & Service Tech	**On-Vehicle & Service Bay/ Depot Tools**	Logged Diagnostic Codes & Parameters available to Service Tech	Paper-based Manuals	On-Board Diagnostics Available
2	Telematics Providing Real-Time Data	Service techs gain real-time vehicle data via remote monitoring of vehicle to more completely capture issues	Operator/Driver, Service Tech & Remote Support Center Advisor	On-Vehicle, Service Bay / Depot & Cloud Data	**Telematic Data Available to Service Tech with Diagnostics Info**	Paper-based Manuals	On-Board & Remote Data Available
Diagnosis & Repair Augmented by Prognosis & Predictive Analytics							
3	Component Level Proactive Alerts	Operator and service techs are provided with component health status (R/Y/G) before problem occurs . Limited condition-based maintenance	Operator/Driver, Service Tech & Cloud-Based Services	On-Vehicle, Service Bay & Cloud Data	Telematic Data Available to Service Tech with Diagnostics Info	**Addition of Component-Level Health Models**	Component-Level Health Predictions
4	Integrated Vehicle Health Mgmt.	Operator and service techs are provided with system or vehicle level health indicators before problems occur with remaining useful life estimated. Condition-based maintenance	Operator/Driver, Service Tech & Cloud-Based Services	On-Vehicle, Service Bay & Cloud Data	Telematic Data Available to Service Tech with Diagnostics Info	Addition of Vehicle-Level Health Models	**Vehicle-Level Health Management**
5	Self-Adaptive Health Mgmt.	Self-adaptive control to extend vehicle operation and enhance safety in presence of potential or actual failures	Operator/Driver, Service Tech & Cloud-Based Services	On-Vehicle, Service Bay & Cloud Data	Telematic Data Available to Service Tech with Diagnostics Info	Addition of Vehicle-Level Health Models	**IVHM Capability Integrated into Vehicle Controls**

Draft

Integrated Vehicle Health Management

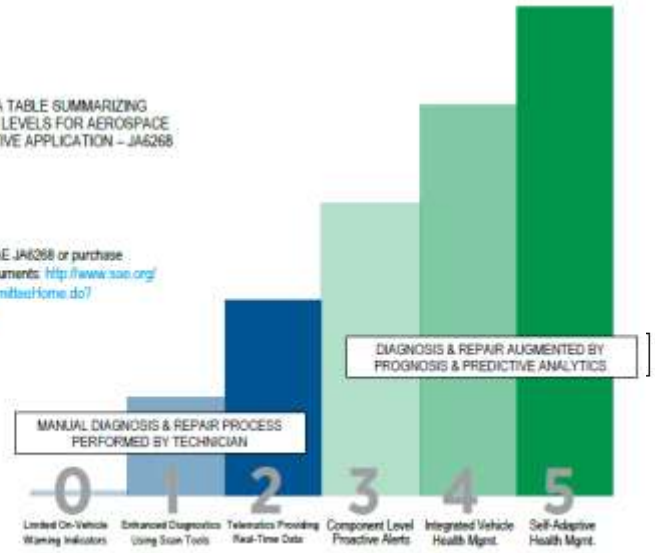
IVHM CAPABILITY LEVELS ARE DEFINED IN FORTHCOMING SAE INTERNATIONAL STANDARD JA6268

With the goal of providing common terminology for Integrated Vehicle Health Management Systems, SAE International's forthcoming standard JA6268: "Design & Online Information Exchange Standard for Health-Ready Components," includes a harmonized classification system and supporting definitions that:

- Identify six levels of IVHM system capability from essentially "no automation" to "self-adaptive health management".
- Base definitions and levels on functional aspects of technology.
- Describe categorical distinctions for a step-wise progression through the levels.
- Are consistent with current industry practice and future directions.
- Eliminate confusion and are useful across numerous disciplines (engineering, legal, media, and public discourse).
- Educate a wider community by clarifying for each level what role maintenance technicians have in performing vehicle repairs.

OVER FOR A TABLE SUMMARIZING CAPABILITY LEVELS FOR AEROSPACE & AUTOMOTIVE APPLICATION – JA6268

Learn more about SAE JA6268 or purchase related standard documents: http://www.sae.org/servlets/works/committeeHome.do?comID=TEAHM1



SUMMARY OF SAE INTERNATIONAL'S CAPABILITY LEVELS FOR AEROSPACE & AUTOMOTIVE APPLICATIONS

Expected publication in April 2017, SAE International's JA6268 was created to help reduce existing barriers to the successful implementation of Integrated Vehicle Health Management (IVHM) technology into the aerospace and automotive sectors. It is motivated by the need to facilitate the introduction of enhanced IVHM functionality relating to supplier-provided components to better meet the needs of end users and government regulators in a cost effective manner.

The report's six capability levels for IVHM span from no automation to self adaptive health management. A key distinction is between level 2 & 3, where prognostics and predictive analytics are brought to bear to significantly enhance the capabilities of the system.

These levels are descriptive rather than normative and technical rather than legal. They imply no particular order of market introduction. Elements indicate minimum rather than maximum system capabilities for each level. A particular system may have multiple IVHM features such that it could operate at different capability levels depending upon the feature(s) that are engaged.

SAE Level	Vehicle Health Capability	Narrative Description	Participation in Repair Actions	Key Data Resources	Availability of Logged &/or Real-Time Data	Use of Supporting Models	IVHM System characteristics
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Diagnosis & Repair Augmented by Prognosis & Predictive Analytics							
3	Component Level Proactive Alerts	Operator and service techs are provided with component health status (HYYG) before problem occurs. Limited condition-based maintenance	Operator/Driver, Service Tech & Cloud-Based Services	On-Vehicle, Service Bay & Cloud Data	Telematic Data Available to Service Tech with Diagnostics Info	Addition of Component-Level Health Models	Component-Level Health Predictions
4	Integrated Vehicle Health Mgmt.	Operator and service techs are provided with system or vehicle level health indications before problems occur with remaining useful life estimates. Condition-based maintenance	Operator/Driver, Service Tech & Cloud-Based Services	On-Vehicle, Service Bay & Cloud Data	Telematic Data Available to Service Tech with Diagnostics Info	Addition of Vehicle-Level Health Models	Vehicle-Level Health Management
5	Self-Adaptive Health Mgmt.	Self-adaptive control to extend vehicle operation and enhance safety in presence of potential or actual failures	Operator/Driver, Service Tech & Cloud-Based Services	On-Vehicle, Service Bay & Cloud Data	Telematic Data Available to Service Tech with Diagnostics Info	Addition of Vehicle-Level Health Models	IVHM Capability Integrated into Vehicle Controls

Key definitions relating to JA6268 include (among others):

Diagnosis is the process of determining the root cause of a problem once a failure has occurred … that is, what part replacement(s) or repair action is necessary to fix the problem.

Prognosis is the process process of predicting the onset of a potential failure mode BEFORE the failure has occurred … while the component is still operating within specs & with sufficient advance notice to avoid the problem.

Integrated Vehicle Health Management refers to the unified capability of a system of systems to assess current or future state of member system health and integrate that picture of system health within a framework of available resources and operational demand (as defined by SAE's IVHM Steering Committee.)

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Introducing Today's Panel

Chair:

- Steve Holland, General Motors

Panelists:

- Barry Einsig, CISCO
- Mohak Shah, Bosch
- Tim Felke, Honeywell
- Mircea Gradu, Hyundai
- Yilu Zhang, General Motors

Barry Einsig

- Barry Einsig: Global Transportation Executive Cisco Systems
  - 17 years working on complex technology challenges in Transportation
  - Currently focused on Automotive Systems
  - Experienced in IP networks, wireless communications, video and physical security systems, critical networks, and wireless technologies

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Mohak Shah

- **Current:**
  - Head of Data Science, and Sr. Principal Scientist,
    Bosch Research, North America
  - Adjunct Research Professor, Univ. of Illinois (Chicago)

- Analytics leader and research scientist with significant experience in organization formation, strategy and end-to-end data science engagements

- Co-author of “Evaluating Learning Algorithms: A Classification Perspective (Cambridge)” and 40+ articles in top refereed journals and conferences in the field

- **Previous:** Leading data science organizations/teams at GE, Accenture and in academia; General Chair, ACM SIGKDD 2016 ; Sr. Member of the ACM;

- PhD in Computer Science (Machine Learning)

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Tim Felke

- 30+ years of experience in Condition Based Maintenance (CBM) and Integrated Vehicle Health Management (IVHM)
- Currently; Engineering Fellow, Honeywell IVHM Systems
- Previously;
  - Senior Technical Manager for Honeywell's Common IVHM Architecture
  - Technical Lead for Deployment of IVHM in Automotive Applications
  - Data Architect for US Army's Platform-Soldier, Mission Readiness System
  - Technical Lead for Diagnostics and Fault Model Development of Central Maintenance Computer (CMC) for Boeing 777 and 787 Aircraft

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Supplier Data and Functional Integration

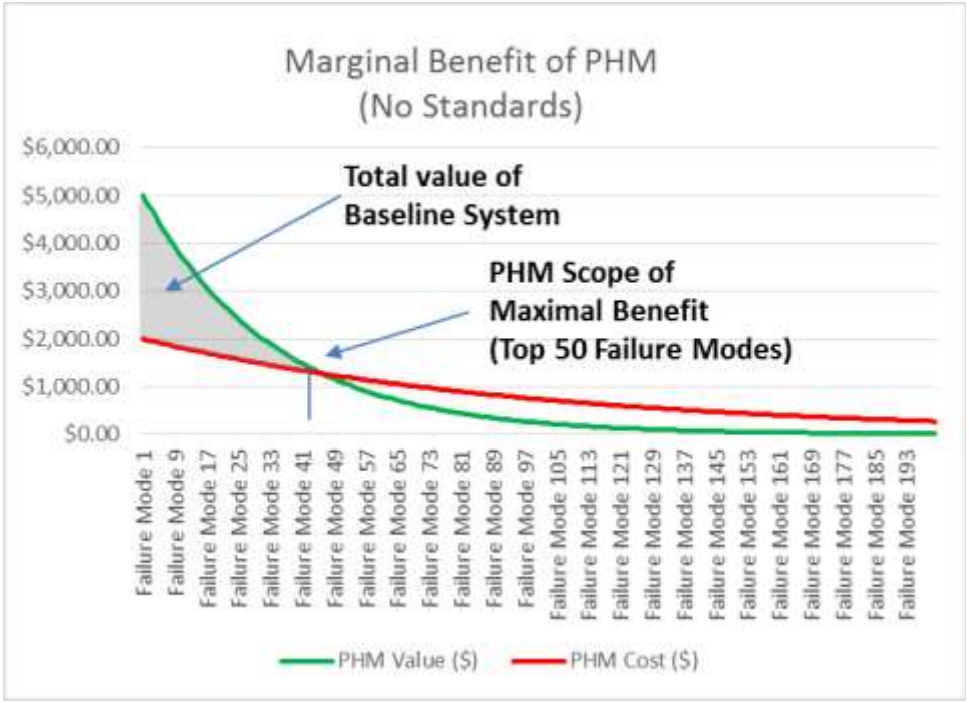
- Most PHM Applications Include Integration of Complex Data and Functionality Provided by Suppliers of Complex Systems and Components.
- Effective Mechanisms to Integrate this Data and Functionality can Greatly Increase the Profitable Scope and Success of PHM Applications.
- JA 6268 is Being Developed to Allow these Mechanisms to be Developed and Improved.

PHM Value Proposition (No Standards)

Critical Failure Modes in some systems have such a large impact on safety or reliability that they are easy to justify:

- Helicopter Transmissions and Bearings
- Main Engines
- Flight Actuation
- Auxiliary Power Units

Remaining Failure Modes are too expensive to monitor and assess so they receive much less support from the PHM system.

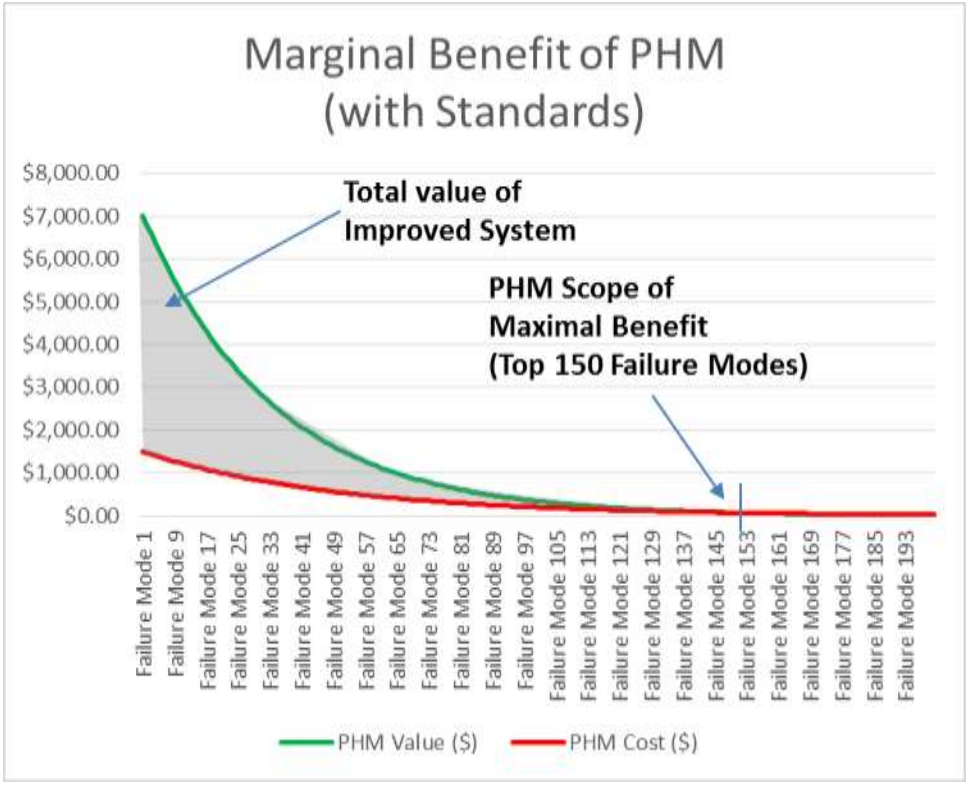


Scope of PHM System Depends on Cost and Value

PHM Value Proposition (with Standards)

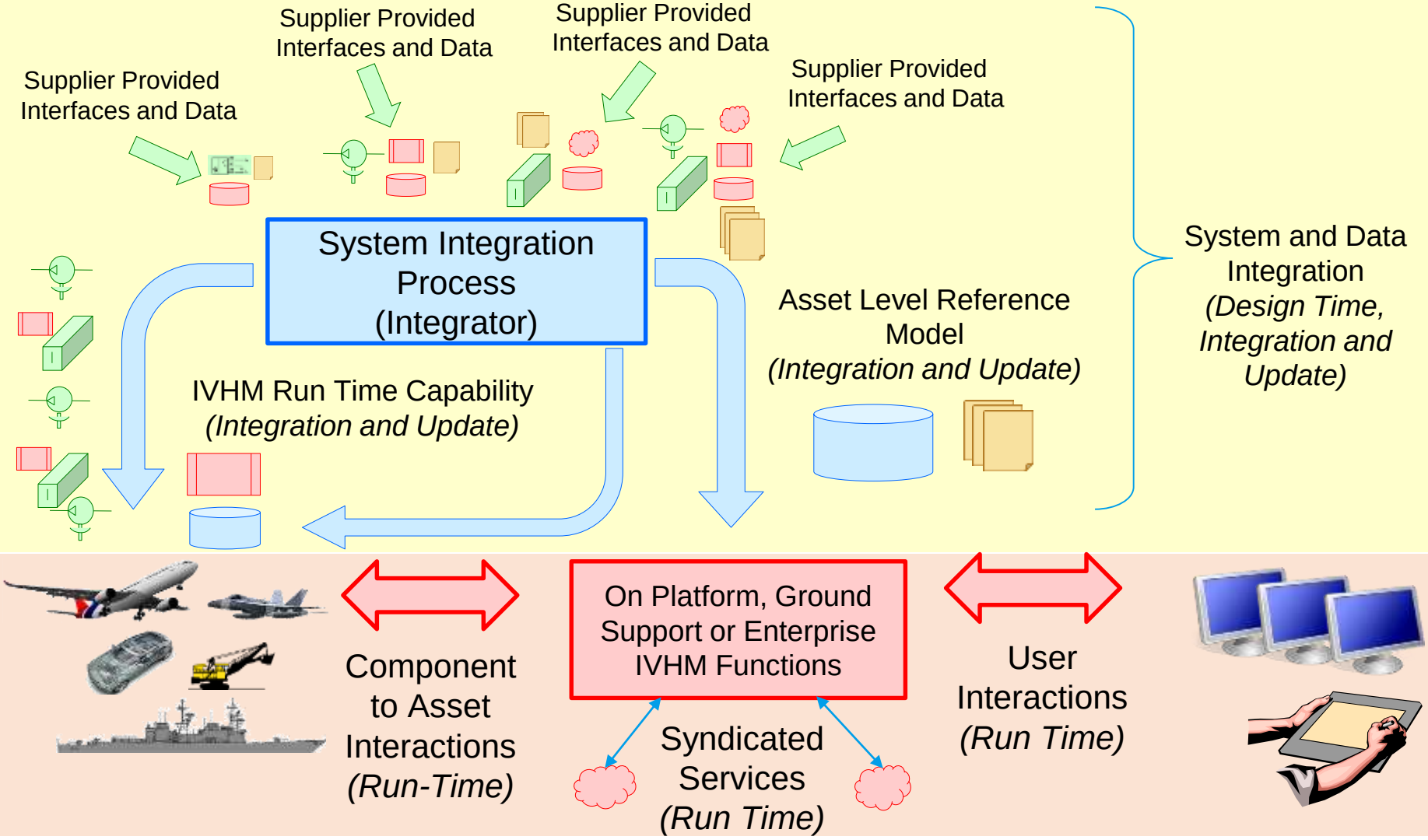
Increase value through development of standards to provide maintenance credits for PHM functionality.

Decrease costs through the development of standards that further reduce development and deployment costs.



The benefits of increasing the value of PHM and decreasing its cost are complementary

JA6268 Application Overview



Mircea Gradu, PhD

- Currently – Executive Director Engineering and Quality at Hyundai Motors America, responsible for: Model Line and Systems Engineering, Vehicle Safety and Cybersecurity, Field Service Engineering, Dealer Tools and Technical Support, Training, Warranty, Alternative Energy Vehicles and Dealer Infrastructure Development (Fuel Cell and Electric Chargers).
- 25 years of automotive experience in R&D, Engineering, Manufacturing, Quality and Service
- Previously - Vice President and Head of Transmission Powertrain and Driveline Engineering for Chrysler Group LLC.
- Recipient of the 2008 Edward Cole Award for Automotive Innovation
- 2005 Forest McFarland Award
- SAE-Timken Howard Simpson Innovation Award from the Society of Automotive Engineers (SAE).
- SAE Fellow since 2011.
- Listed among the 50 most influential automotive executives in 2012 by Motor Trend.
- Awarded 56 patents on mechatronic automotive systems, and published over 40 papers.
- Doctorate in Mechanical Engineering from the University of Stuttgart, Germany and a Master's degree in Mechanical Engineering from the Polytechnic Institute of Bucharest.

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Yilu Zhang

- Group Manager of Vehicle Health Management, Vehicle Systems Research Lab at GM Global R&D
- Three-time recipient of GM Boss Kettering Award, the most prestigious technology award in GM to recognize “stretch thinkers and drivers of innovation”
- Awarded 29 patents, and published 59 papers
- PhD in Computer Science from Michigan State University, MS and BS in Control from Zhengjiang University, China
- IEEE Senior Member

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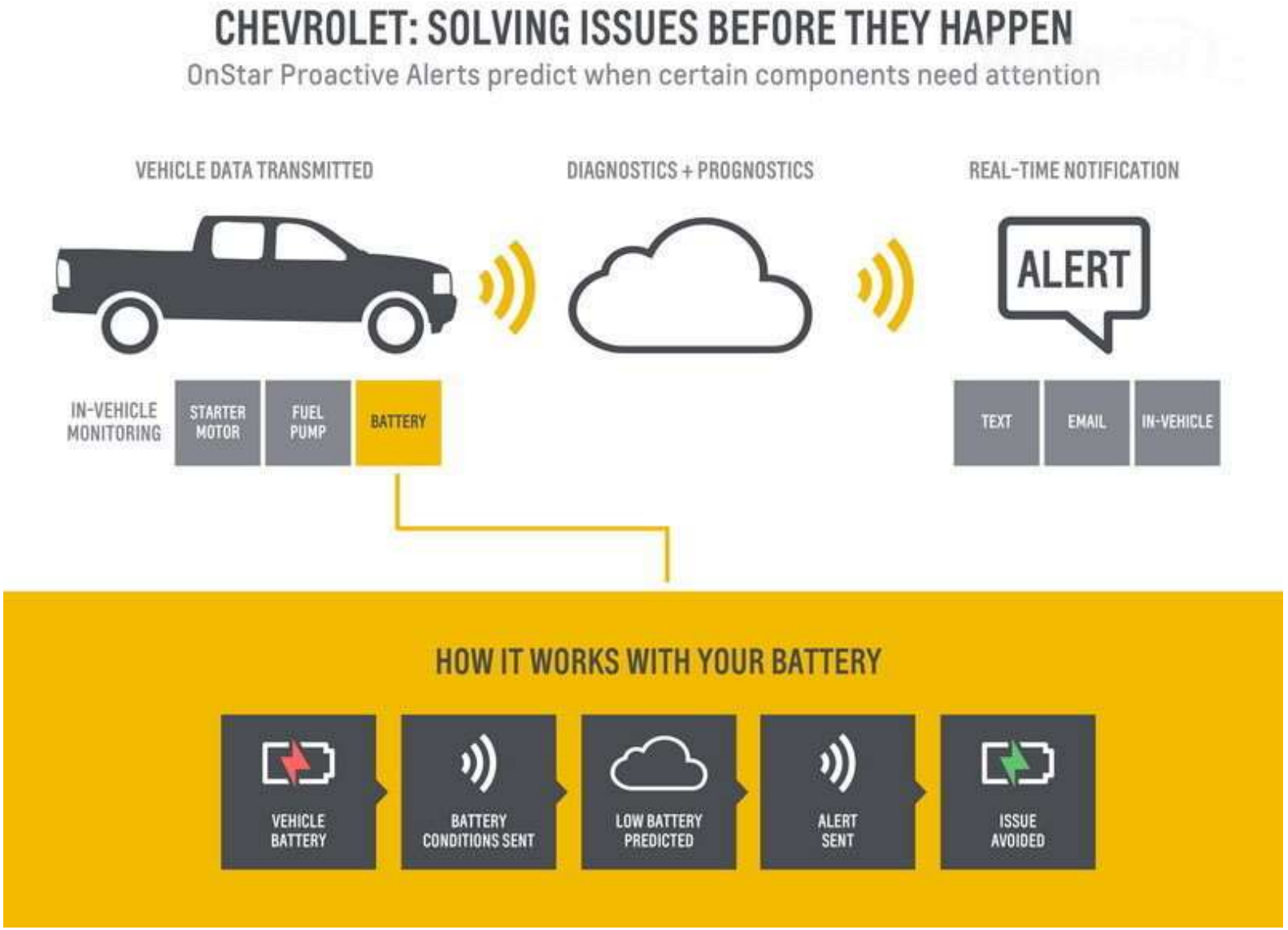
- Everything wears out over time
- Customer's life is disrupted, when his/her vehicle needs repair unexpectedly
- The solution - Vehicle Health Management (VHM)
  - Alert before failure happens
  - Transform an emergency repair to planned maintenance
  - Enhance ownership experience - a delight to customers
- Introducing OnStar™ Proactive Alerts - a new customer care service


CHEVROLET: SOLVING ISSUES BEFORE THEY HAPPEN
OnStar Proactive Alerts predict when certain components need attention
VEHICLE DATA TRANSMITTED
DIAGNOSTICS + PROGNOSTICS
REAL-TIME NOTIFICATION
ALERT
IN-VEHICLE MONITORING
STARTER MOTOR
FUEL PUMP
BATTERY
TEXT
EMAIL
IN-VEHICLE
HOW IT WORKS WITH YOUR BATTERY
VEHICLE BATTERY
BATTERY CONDITIONS SENT
LOW BATTERY PREDICTED
ALERT SENT
ISSUE AVOIDED

Where are we today on OnStar™ Proactive Alerts?

- Launched on
  - 2016 Chevrolet Equinox
  - 2016 Chevrolet Tahoe
  - 2016 Chevrolet Suburban
  - 2016 Chevrolet Corvette
  - 2016 Chevrolet Silverado
  - 2016 GMC Terrain
  - 2016 GMC Yukon
  - 2016 GMC Sierra
  - 2016 Cadillac Escalade
- Currently cover three critical components
  - battery, starter, fuel pump
- Will be extended to more GM vehicle programs and cover other critical vehicle components over time

Beyond Prognostics – VHM impacts automotive value chain


Supplier


Vehicle development


Manufacturing


Sales


Ownership


Service

Selected Thought Starter Questions

1. What are the challenges of large scale PHM deployment?
2. What are the best practices for OEM/Supplier collaboration?
3. How can we avoid duplication of effort between OEMs and Suppliers?
4. What are Health-Ready Components?
5. What strategies will help us avoid IP issues & concerns?
6. How to get component & system designers to consider the Prognosis Paradigm and build in the hooks?
7. How can international standards promote the application of PHM?
8. Has your management “bought in?” What arguments were effective?
9. What fundamental research would you like to see from the academia?